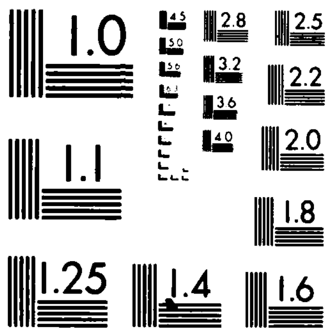
AD-A172 415 A HOT GAS SOURCE FOR CONVECTIVE IGNITION STUDIES OF ENERGETIC MATERIALS(U) ARMY BALLISTIC RESEARCH LAB ABERDEEN PROVING GROUND MD M A DEWILDE AUG 86 1/1

UNCLASSIFIED BRL-MR-3543 F/G 21/2 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(12)

AD-A172 415

AD

US ARMY MATERIEL COMMAND

MEMORANDUM REPORT BRL-MR-3543

A HOT GAS SOURCE FOR CONVECTIVE IGNITION STUDIES OF ENERGETIC MATERIALS

Mark A. DeWilde

August 1986

US ARMY BALLISTIC RESEARCH LABORATORY
ABERDEEN PROVING GROUND, MARYLAND

86 10 2 0??

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Memorandum Report BRL-MR-3543	2. GOVT ACCESSION NO. AD-A172 415	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A HOT GAS SOURCE FOR CONVECTIVE IGNITION STUDIES OF ENERGETIC MATERIALS		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Mark A. DeWilde		8. CONTRACT OR GRANT NUMBER(s) 1L161102AH43
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Ballistic Research Laboratory ATTN: SLCBR-IB Aberdeen Proving Ground, MD 21005-5066		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Ballistic Research Laboratory ATTN: SLCBR-DD-T Aberdeen Proving Ground, MD 21005-5066		12. REPORT DATE August 1986
		13. NUMBER OF PAGES 23
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE NA
16. DISTRIBUTION STATEMENT (of this Report) Approved for Public Release; Distribution Unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Convective Ignition Hot Gas Source Furnaces		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) meg,jmk A novel hot gas source is described that possesses the capability of producing a continuous laminar flow of hot gas at temperatures from ambient to 900°C. Details of construction are given and a short description of intended application is provided.		

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

ACKNOWLEDGEMENTS

The author wishes to acknowledge Mr. Wade Scott for taking the pitot tube measurements in the table.

TABLE OF CONTENTS

LIST OF FIGURES

I. INTRODUCTION

In order to understand the ignition of propellant grains in a charge within a gun, it is desirable to study how the evolved hot gases that permeate the bed and flow over the individual grains cause ignition of those grains. The temperatures of these gases range from ambient, to the adiabatic flame temperatures characteristic of the propellant in use. The composition of the gases ranges from that of air, to mixtures of partial combustion products with air. The flows may be either laminar or turbulent. The difficulties of designing an apparatus to simulate all such conditions, led to the chosen regime, that of the early stages of bed ignition. In these stages, temperatures range from ambient to approximately 1000°C, flows are laminar, or just starting to break up into turbulence, and the gases are essentially air, or oxygen depleted air. The apparatus described produces these conditions.

II. DESIGN, CONSTRUCTION, MATERIALS*

The design of the active portion of the apparatus is shown in Figure 1. The system consists of five heat exchangers and six ceramic insulated heating elements, alternately stacked. The heat exchangers are plumbed in series as is shown in the figure. The entire assembly is placed in an insulating container to minimize heat loss and maximize ultimate attainable temperature. Figure 2 illustrates the design of one of the heat exchangers. The material chosen for construction was type 304 stainless steel, mainly for reasons of being on hand, although monel would be the material of choice for units subsequent to the original test model. Each exchanger consists of a single plate with long holes drilled through the length at equal spacings. To interconnect these drilled gas passages into a single path, channels are milled into the end of the plate between adjacent holes. Finally, small plates are welded over the channels to complete the closure of the gas passage. The total path length through each exchanger is 46 inches. Note that inlet and outlet are on the same end of the heat exchangers block. The heating elements (used for reasons of being on hand) were from the Lindberg Furnace Company, Model 7217100400C, rated at 625 watts 60 volts. The wiring of these elements is shown in Figure 3. The insulating material is four inches of standard insulating firebrick from the Babcock-Wilcox Company. The entire assembly is placed in a sheet metal box that is centered inside of another slotted sheet metal box, four to five inches larger in each dimension. This outer box provides ventilation around the inner box, and prevents any hot surfaces from being accessible by the user. An in-house fabricated heated nozzle is put on the outlet of the gas source, and serves to enlarge and laminarize the exiting flow. This nozzle is shown in Figure 4. A standard laboratory combustion tube furnace, one inch inside diameter, overall length of four to five inches is placed over the nozzle. The function of this tube furnace is to eliminate the cooling by the nozzle of the hot gas exiting the furnace. Initially, insulating material around the nozzle was tried, but due to the low heat capacity of air, and the high temperature differentials

*The use of manufacturer's names and model numbers is not be be construed as an endorsement by the US Government. They are provided as a reference to the types of equipment used, and any equal product can be substituted.

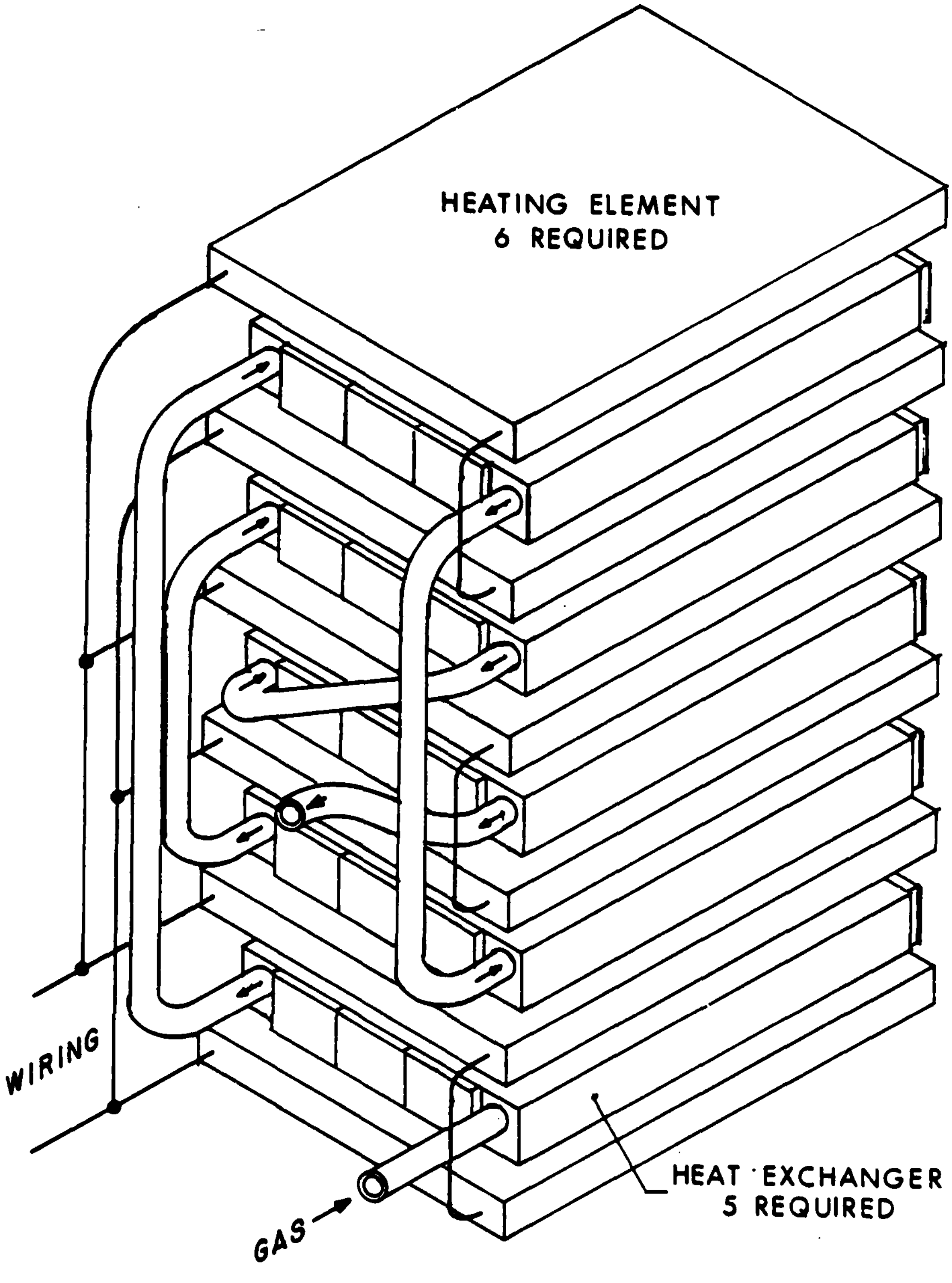


Figure 1. Working Elements of Gas Source

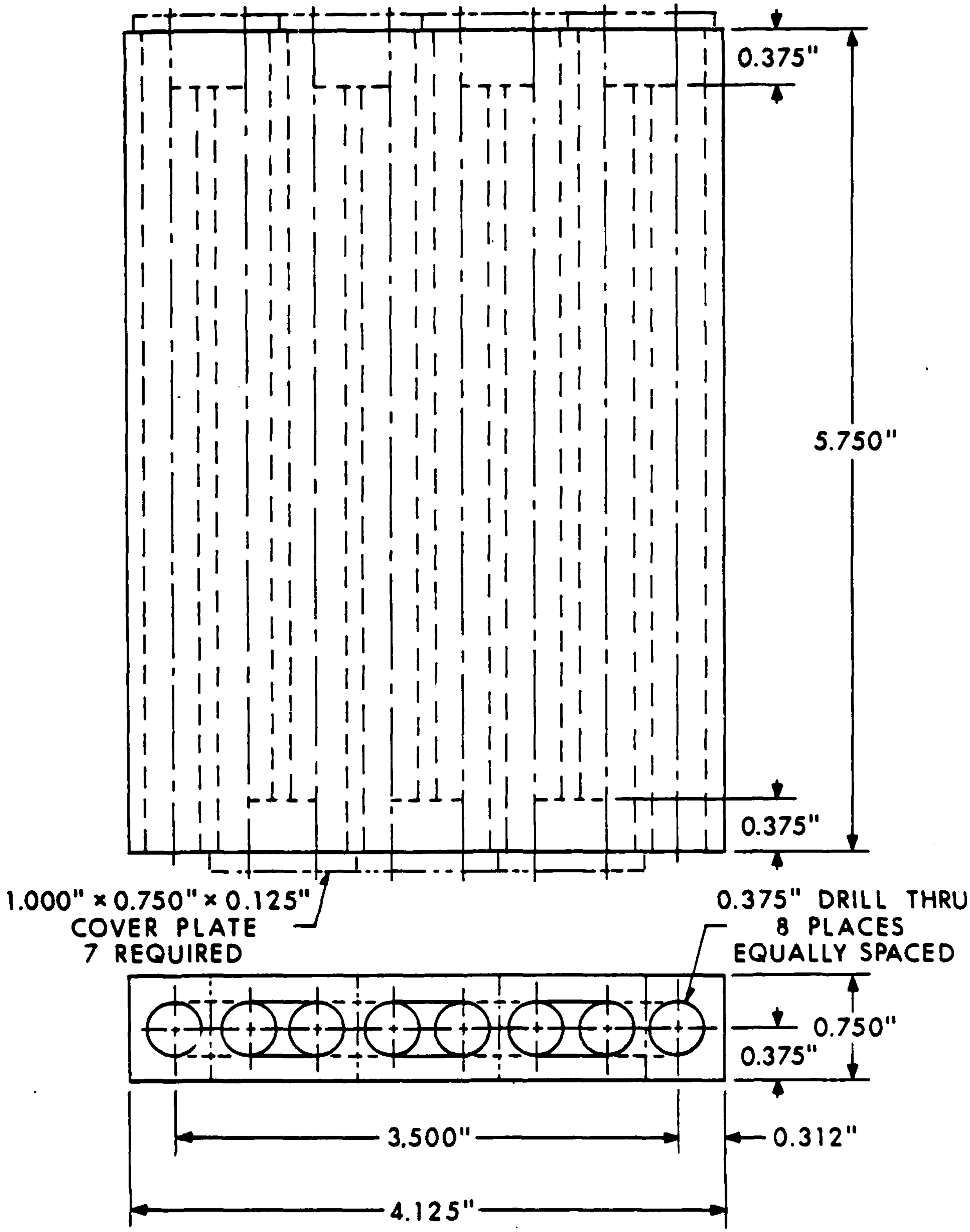


Figure 2. Design of Heat Exchangers

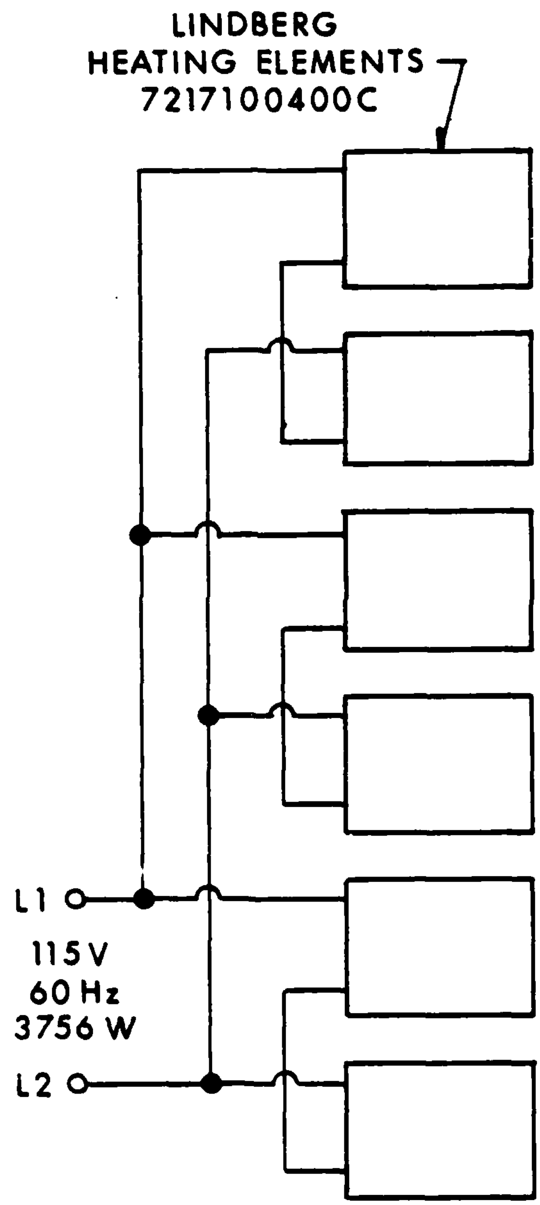


Figure 3. Wiring of Heating Elements

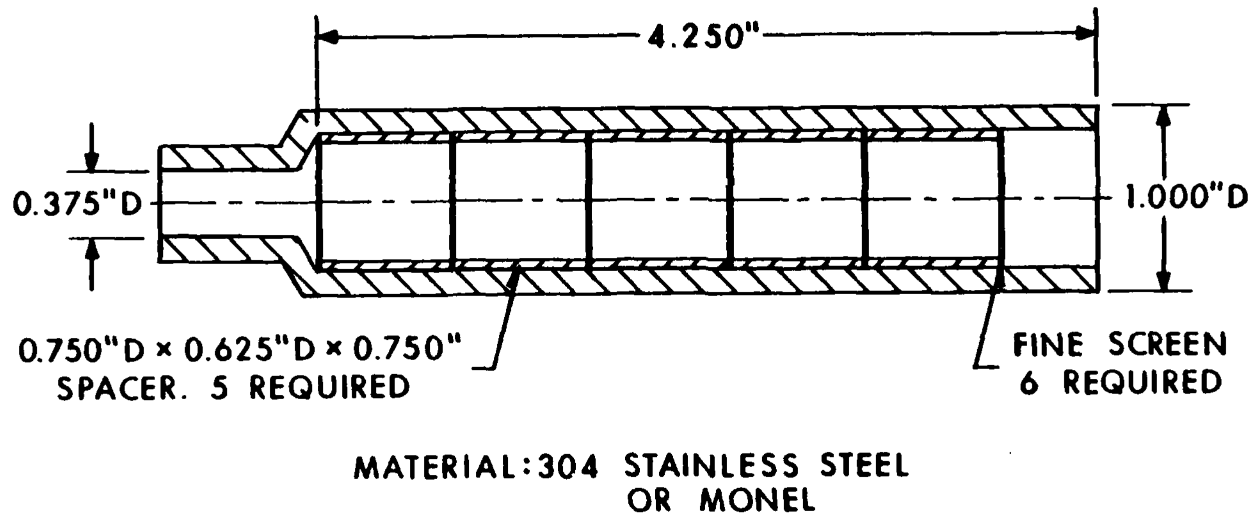


Figure 4. Outlet Laminarization Nozzle

involved, the nozzle always stabilized at a temperature considerably lower than that of the heat exchangers. The active heating method was adopted and solved the problem that the insulation did not. Figure 5 illustrates the completed furnace with the front insulation removed, and Figure 6, the external completed appearance. Not shown in the illustrations are temperature controllers for the heat exchangers and nozzle heaters. These are used to set the operating parameters desired.

III. TYPICAL OPERATING PARAMETERS

In order to check the flow profile exiting the nozzle, pitot tube measurements were taken at 0.100 inch increments across the nozzle, at a distance of 0.4 inch from the end of the nozzle. Initial data as shown in the table for a supply pressure of 40 psi into the furnace, with air at ambient temperatures demonstrated a distinct dip in the flow profile at the center of the nozzle. This was found to be caused by depressions in the center of the screens, and was eliminated by more careful fabrication. After this improvement, the flow at the center became flat to within experimental error.

TABLE 1. PITOT TUBE MEASUREMENTS ACROSS NOZZLE

Position (inches)	Pitot Pressure (mm Hg.)
0.0	0.00
0.1	0.59
0.2	1.42
0.3	1.35
0.4	1.30
0.5	1.30
0.6	1.39
0.7	1.37
0.8	1.36
0.9	0.43
1.0	0.00

The typical operating temperatures used ranged from ambient to 1200°C for the heat exchangers, and ambient to 1000°C for the nozzle heater. Typically, the nozzle is held at the desired discharge temperature, and the heat exchangers at the same temperature for very slow gas flows, or up to 200°C warmer for higher flow rates. Figure 7 shows a shadowgraph of the gas exiting the gas source, and indicates the laminar nature at this flow rate for a distance downstream of the nozzle. The temperature of the gas for these measurements was 800°C. Thermocouple measurements at a distance of 0.5 inches from the nozzle indicate an operating temperature of 1000°C is attainable, although extended operation at this temperature considerably shortens the life of the heat exchangers When dry nitrogen gas was heated to 630°C and combustible materials placed in the gas flow, they could be made to pyrolyze, but not burn until withdrawn from the flow into the oxygen containing room air. If, however, gun propellants such as M-30 are placed in that same flow, vigorous ignition and burning with little smoke occurs, thus simulating the ignition of such materials in the oxygen-deficient gases in a gun tube. Further studies using this tool are in progress. It was found that once the

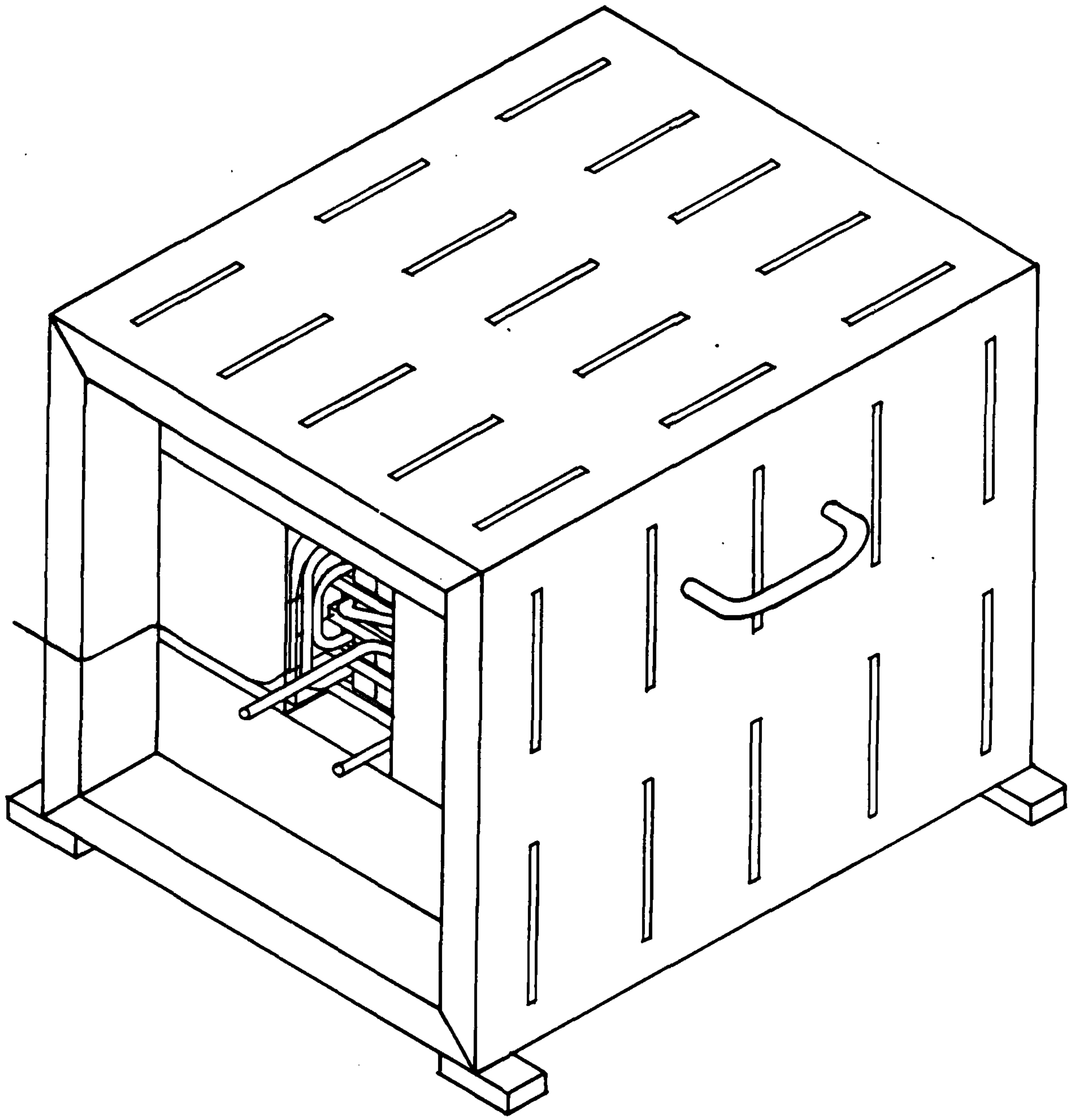


Figure 5. Gas Source Interior View

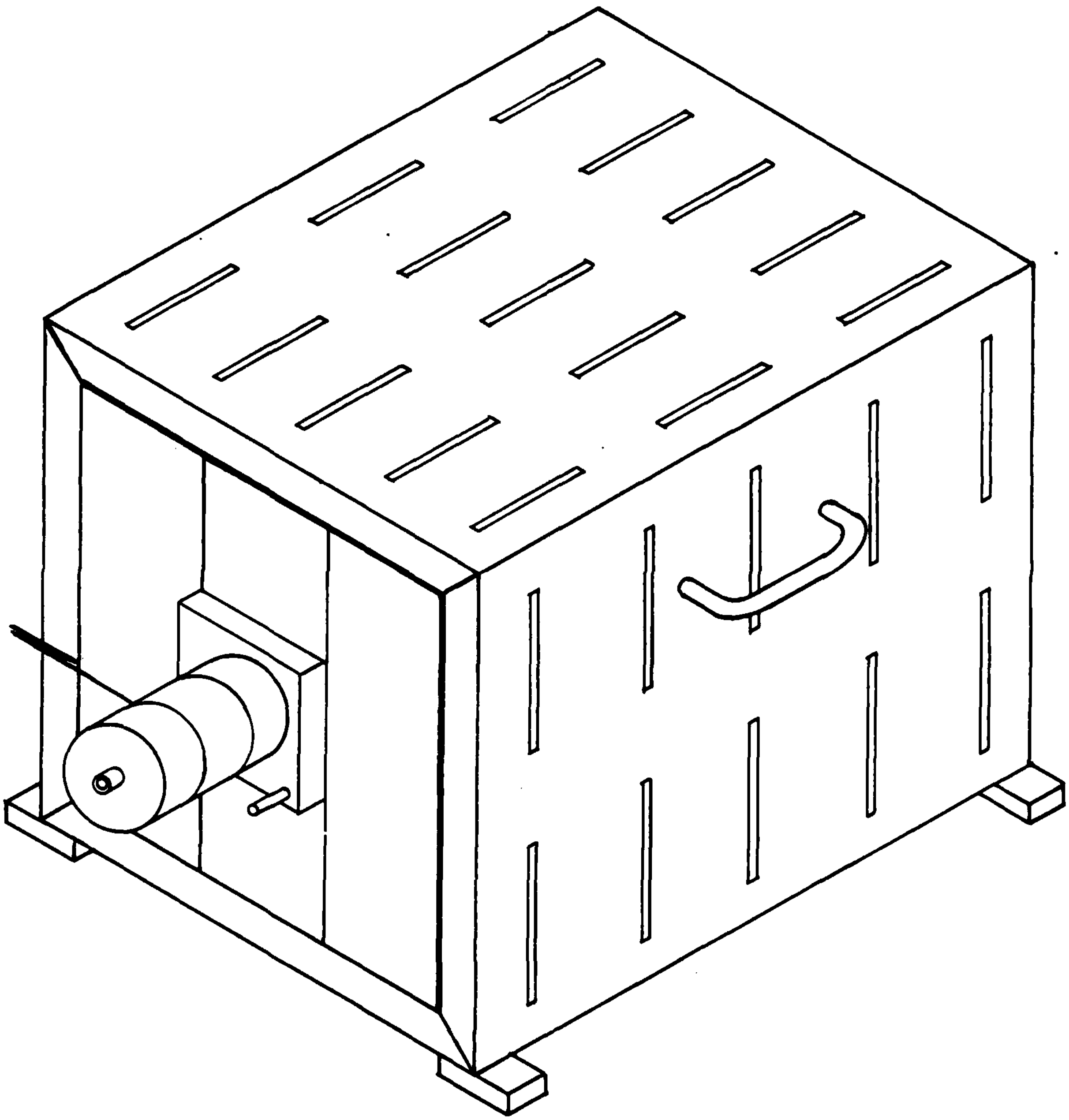


Figure 6. Completed Gas Source

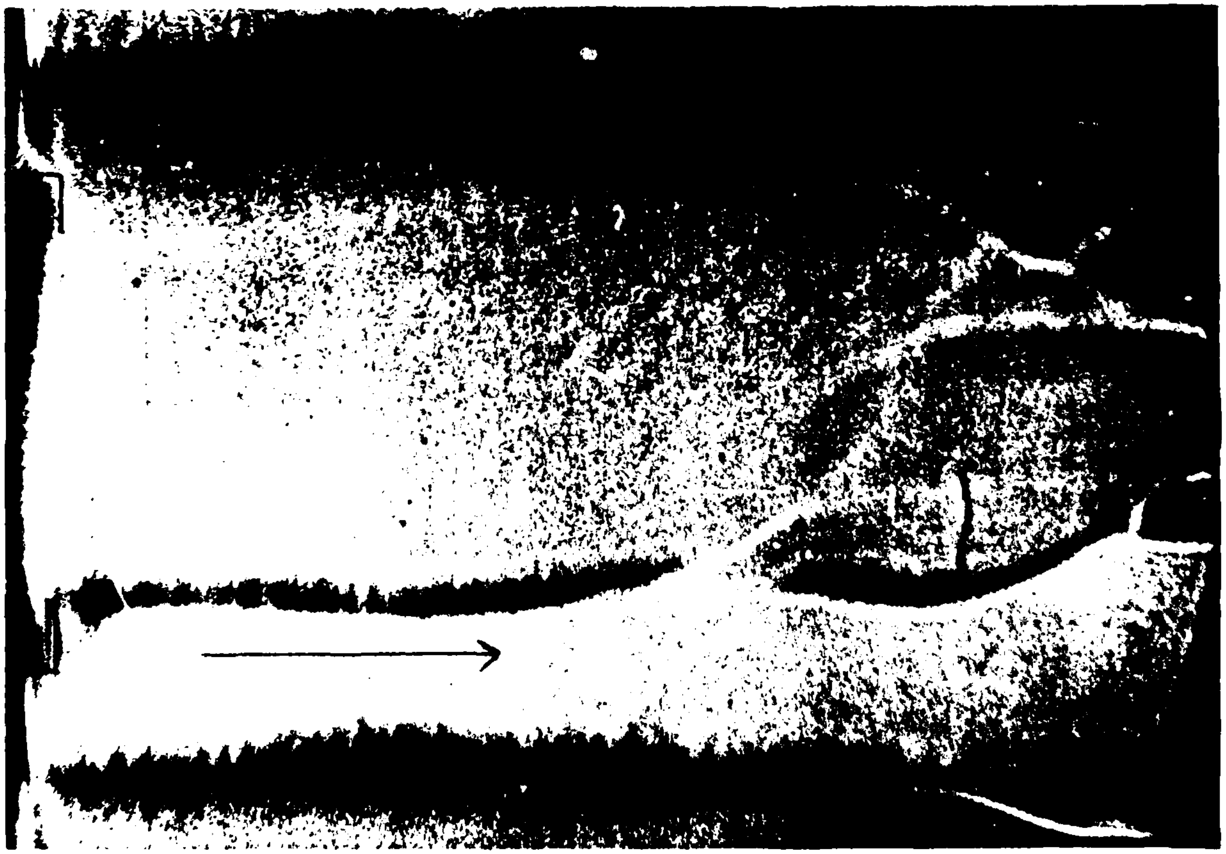


Figure 7. Shadowgraph of Flow

gas source has heated to the desired operating temperatures, the operation is steady state, i.e., there is extremely little drift in the outlet temperature over extended periods of time.

Warmup times for this furnace depend on temperature, and reach a maximum of two hours at 1000°C. The measurement times for thermal stability were 20 minutes, during which variations of ± 5 degrees were observed, caused by the on-off heating cycles of the temperature controller. The use of power proportioning rather than time proportioning controllers could be expected to lessen this variation. The specific heat of air at 1000°C is approximately 0.257 cal/gm. At the same temperature, the density is approximately 2.7×10^{-4} g/cc. This yields a heat capacity of 7.1×10^{-5} cal/cc-deg C. The lowest and highest linear flow velocity of the nozzle were measured to be 1 cm/sec to 7 m/sec. The amount of heat available to a one square cm. area object of infinitesimal thickness blocking the flow for each degree of cooling of the gas ranges then from 7.1×10^{-5} cal/sec to 520.7 cal/sec. Actual heat transfer to the object and cooling of the gas flow depends on shape, thermal conductivity of both gas and object, orientation, and numerous other factors. For the qualitative sorts of observations needed in the studies of propellant convective ignition* these considerations were not of prime importance.

IV. CLOSING COMMENTS

The hot gas source described in this report has proven to have applications other than those originally intended. One researcher has duplicated this device and uses it to provide a flow of hot gas for environmental control within a high pressure propellant strand burner. Since the flows produced are laminar and their temperatures can be measured directly with thermocouples, they provide a convenient way to calibrate and test optical thermometry techniques in this temperature regime. Although not used for this purpose to date, the source should provide an excellent heat source for measuring heat flows into small objects and could be useful in convective heating and heat flow measurements.

*Beyer, R.A., DeWilde, M.A., "Convective Heating of Energetic Materials," Ballistic Research Technical Report, BRL-TR-2701, December 1985.

DISTRIBUTION LIST

No of Copies	Organization
12	Administrator Defense Technical Info Center ATTN: DTIC-DDA Cameron Station Alexandria, VA 22314
1	HQ DA DAMA-ART-M Washington, DC 20310
1	Commander US Army Materiel Cmd. ATTN: AMCDRA-ST 5001 Eisenhower Avenue Alexandria, VA 22333
1	Commander Armament R&D Center USA AMCCOM ATTN: SMCAR-TDC Dover, NJ 07801-5001
2	Commander Armament R&D Center USA AMCCOM ATTN: SMCAR-TSS Dover, NJ 07801-5001
1	Commander US Army Armament, Munitions and Chemical Cmd ATTN: SMCAR-ESP-L Rock Island, IL 61299
1	Director Benet Weapon Laboratory Armament R&D Center USA AMCCOM ATTN: SMCAR-LCB-TL Watervliet, NY 12189
1	Commander USA Aviation Rsch and Development Cmd ATTN: AMSAV-E 4300 Goodfellow Blvd. St. Louis, MO 63120

No. of Copies	Organization
1	Director USA Air Mobility Rsch and Development Lab. Ames Research Center Moffett Field, CA 94035
4	Commander USA Research Officer ATTN: R. Ghirardelli D. Mann R. Singleton R. Shaw Research Triangle Park NC 27709
1	Commander ERADCOM Technical Library ATTN: DELSD-L (Reports Section) Fort Monmouth, NJ 07703-5301
1	Commander USA Electronics Rsch and Development Cmd Technical Support Activity ATTN: DELSD-L Fort Monmouth, NJ 07703
2	Commander USA AMCCOM ATTN: DRSMC-LCA-G D.S. Downs J.A. Lannon Dover, NJ 07801
1	Commander USA AMCCOM ATTN: DRSMC-LC, L. Harris Dover, NJ 07801
1	Commander USA AMCCOM ATTN: DRSMC-SCA-T L. Stiefel Dover, NJ 07801

DISTRIBUTION LIST

No of Copies	Organization
1	Commander USA Missile Command Research, Development, Engineering Center ATTN: AMSMI-RD Redstone Arsenal, AL 35898
1	Commander USA Missile & Space Command Intelligence Center ATTN: AIAMS-YDL Redstone Arsenal, AL 35898
2	Commander USA Missile Command ATTN: DRSMI-RK, D.J. Ifshin Redstone Arsenal, AL 35898
1	Commander USA Tank Automotive Cmd ATTN: AMSTA-TSL Warren, MI 48397-5000
1	Director USA TRADOC Systems Analysis ATTN: ATAA-SL WSMR, NM 88002
2	Commandant USA Infantry School ATTN: ATSH-CD-CSO-OR Fort Benning, GA 31905
1	Commander USA Development and Employment Agency ATTN: MODE-TED-SAB Fort Lewis, WA 98433
1	Office of Naval Rsch Department of the Navy ATTN: R.S. Miller, Code 432 800 N. Quincy Street Arlington, VA 22217
1	Navy Strategic Systems Project Office ATTN: R.D. Kinert, SP 2721 Washington, DC 20376
1	Commander Naval Air Systems Cmd ATTN: J. Ramnarace, AIR-54111C Washington, DC 20360
3	Commander Naval Ordnance Station ATTN: C. Irish S. Mitchell P.L. Stang, Code 515 Indian Head, MD 20640
1	Commander Naval Surface Weapons Center ATTN: J.L. East, Jr., G-20 Dahlgren, VA 22448
2	Commander Naval Surface Weapons Center ATTN: R. Bernecker, R-13 G.B. Wilmot, R-16 Silver Spring, MD 20910
4	Commander Naval Weapons Center ATTN: R.L. Derr, Code 389 China Lake, CA 93555
2	Commander Naval Weapons Center ATTN: Code 3891, T. Boggs K.J. Graham China Lake, CA 93555
5	Commander Naval Research Lab, Code 6110 ATTN: L. Harvey J. McDonald E. Oran J. Shnur R.J. Doyle, Washington, DC 20375

DISTRIBUTION LIST

No of Copies	Organization
1	Commanding Officer Naval Underwater System Center Weapons Dept. ATTN: R.S. Lazar/Code 36301 Newport, RI 02840
1	Superintendent Naval Postgraduate School Dept. of Aeronautics ATTN: D.W. Netzer Monterey, CA 93940
6	AFRPL (DRSC) ATTN: R. Geisler D. George B. Goshgarian J. Levine W. Roe D. Weaver Edwards AFB, CA 93523
1	Air Force Armament Laboratory ATTN: AFATL/DLODL ATTN: O.K. Heiney Eglin AFB, FL 32542-5000
2	AFOSR ATTN: L.H. Caveny J.M. Tishkoff Bolling Air Force Base Washington, DC 20332
1	AFWL/SUL Kirtland AFB, NM 87117
1	NASA Langley Research Center ATTN: G.B. Northam/MS 168 Hampton, VA 23365
4	National Bureau of Standards ATTN: J. Hastie M. Jacox T. Kashiwagi H. Semerjian US Dept. of Commerce Washington, DC 20234

No. of Copies	Organization
1	Aerojet Solid Propulsion Company ATTN: P. Micheli Sacramento, CA 95813
1	Applied Combustion Technology, Inc. ATTN: A.M. Varney P.O. Box 17885 Orlando, FL 32860
2	Atlantic Research Corp. ATTN: M.K. King 5390 Cherokee Avenue Alexandria, VA 22314
1	Atlantic Research Corp. ATTN: R.H.W. Waesche 7511 Wellington Road Gainesville, VA 22065
1	AVCO Everett Research laboratory Division ATTN: D. Stickler 2385 Revere Beach Parkway Everett, MA 02149
1	Battelle Memorial Institute Tactical Technology Center ATTN: J. Huggins 505 King Avenue Columbus, OH 43201
2	Exxon Research & Engineering Company ATTN: A. Dean M. Chou P.O. Box 45 Linden, NJ 07036
1	Ford Aerospace and Communications Corp. DIVAD Division Div. Hq., Irvine ATTN: D. Williams Main Street & Ford Road Newport Beach, CA 92663

DISTRIBUTION LIST

No of Copies	Organization
1	General Electric Armament & Electrical Systems ATTN: M.J. Bulman Lakeside Avenue Burlington, VT 05402
1	General Electric Co. ATTN: M. Lapp Schenectady, NY 12301
1	General Electric Ordnance Systems ATTN: J. Mandzy 100 Plastics Avenue Pittsfield, MA 01203
1	General Motors Rsch Lab Physics Department ATTN: R. Teets Warren, MI 48090
3	Hercules, Inc. Alleghany Ballistics Lab. ATTN: R.R. Miller P.O. Box 210 Cumberland, MD 21501
3	Hercules, Inc. Bacchus Works ATTN: K.P. McCarty P.O. Box 98 Magna, UT 84044
1	Hercules, Inc. AFATL/DLDL ATTN: R.L. Simmons Eglin AFB, FL 32542
1	Honeywell, Inc. Defense Systems Div. ATTN: D.E. Broden/ MS MN50-2000 600 2nd Street NE Hopkins, MN 55343

No. of Copies	Organization
1	IBM Corporation ATTN: A.C. Tam Research Division 5600 Cottle Road San Jose, CA 95193
1	Director Lawrence Livermore National Laboratory ATTN: C. Westbrook Livermore, CA 94550
1	Lockheed Missiles & Space Company ATTN: George Lo 3251 Hanover Street Dept. 52-35/B204/2 Palo Alto, CA 94304
1	Los Alamos National Lab ATTN: B. Nichols T7, MS-B284 P.O. Box 1663 Los Alamos, NM 87545
1	Olin Corporation Smokeless Powder Operations ATTN: R.L. Cook P.O. Box 222 St. Marks, FL 32355
1	Paul Gough Associates ATTN: P.S. Gough 1048 South Street Portsmouth, NH 03801
2	Princeton Combustion Research Labs, Inc. ATTN: M. Summerfield N.A. Messina 475 US Highway One Monmouth Junction, NJ 08852
1	Hughes Aircraft Company ATTN: T.E. Ward 8433 Fallbrook Avenue Canoga Park, CA 91303

DISTRIBUTION LIST

No of Copies	Organization
1	Rockwell International Corporation Rocketdyne Division ATTN: J.E. Flanagan/HB02 6633 Canoga Avenue Canoga Park, CA 91304
3	Sandia National Labs. Combustion Science Dept ATTN: R. Cattolica D. Stephenson P. Mattern Livermore, CA 94550
1	Sandia National Labs. ATTN: M. Smooke Division 8353 Livermore, CA 94550
1	Science Applications, Inc. ATTN: R.B. Edelman 23146 Cumorah Crest Woodland Hills, CA 91364
2	Univ. of California, Santa Barbara Quantum Institute ATTN: K. Schofield M. Steinberg Santa Barbara, CA 93106
1	University of Southern California Dept. of Chemistry ATTN: S. Benson Los Angeles, CA 90007
1	Case Western Reserve University Division of Aerospace Science ATTN: J. Tien Cleveland, OH 44135
1	Cornell University Department of Chemistry ATTN: E. Grant Baker Laboratory Ithaca, NY 14853

No. of Copies	Organization
1	University of Dayton Research Institute ATTN: D. Campbell AFRPL/PAP Stop 24 Edwards AFB, CA 93523
1	University of Florida Dept. of Chemistry ATTN: J. Winefordner Gainesville, FL 32611
3	Georgia Inst. of Technology School of Aerospace Eng. ATTN: E. Price Atlanta, GA 30332
2	Georgia Institute of Technology School of Aerospace Eng. ATTN: W.C. Strahle B.T. Zinn Atlanta, GA 30332
1	University of Illinois Dept. of Mech. Eng. ATTN: H. Krier 144 MEB, 1206 W.Green Street Urbana, IL 61801
1	Johns Hopkins Univ./APL Chemical Propulsion Information Agency ATTN: T.W. Christian Johns Hopkins Road Laurel, MD 20707
1	University of Minnesota Dept. of Mechanical Eng. ATTN: E. Fletcher Minneapolis, MN 55455
4	Pennsylvania State University Applied Research Lab. ATTN: G.M. Faeth K.k. Kuo H. Palmer M. Micci University Park, PA 16802

DISTRIBUTION LIST

No of Copies	Organization	No. of Copies	Organization
1	Polytechnic Institute of NY ATTN: S. Lederman Route 110 Farmingdale, NY 11735	1	Thiokol Corporation Elkton Division ATTN: W.N. Brundige P.O. Box 241 Elkton, MD 21921
2	Princeton University Forrestal Campus Library ATTN: K. Brezinsky I. Glassman P.O. Box 710 Princeton, NJ 08540	3	Thiokol Corporation Huntsville Division ATTN: D.A. Flanagan Huntsville, AL 35807
1	Princeton University MAE Dept. ATTN: F.A. Williams Princeton, NJ 08544	3	Thiokol Corporation Wasatch Division ATTN: J.A. Peterson P.O. Box 524 Brigham City, UT 84302
1	Science Applications, Inc. ATTN: H.S. Pergament 1100 State Road, Bldg. N Princeton, NJ 08540	1	United Technologies ATTN: A.C. Eckbreth East Hartford, CT 06108
1	Space Sciences, Inc. ATTN: M. Farber Monrovia, CA 91016	2	United Technologies Corp. ATTN: R.S. Brown R.O. McLaren P.O. Box 358 Sunnyvale, CA 94088
4	SRI International ATTN: S. Barker D. Crosley D. Golden Tech. Lib 333 Ravenwood Avenue Menlo Park, CA 94025	1	Universal Propulsion Company ATTN: H.J. McSpadden Black Canyon Stage 1 Box 1140 Phoenix, AX 85029
1	Stevens Institute of Technology Davidson Laboratory ATTN: R. McAlevy, III Hoboken, NJ 07030	1	Veritay Technology, Inc. ATTN: E.B. Fisher P.O. Box 22 Bowmansville, NY 14026
1	Teledyne McCormack-Selph ATTN: C. Leveritt 3601 Union Road Hollister, CA 95023	1	Brigham Young Univ. Dept. of Chemical Eng. ATTN: M.W. Beckstead Provo, UT 84601
		1	California Institue of Technology Jet Propulsion Lab. ATTN: MS 125/159 4800 Oak Grove Drive Pasadena, CA 91103

DISTRIBUTION LIST

No of Copies	Organization
1	California Institue of Technology ATTN: F.E.C. Culick/ MC 301-46 204 Karman Lab. Pasadena, CA 91125
1	Univ. of California, Berkeley Mechanical Engineering Department ATTN: J. Daily Berkeley, CA 94720
1	Univ. of California Los Alamos National Laboratory ATTN: T.D. Butler P.O. Box 1663, Mail Stop B216 Los Alamos, NM 87545
2	Purdue University School of Aeronautics and Astronautics ATTN: R. Glick J.R. Osborn Grissom Hall West Lafayette, IN 47907
3	Purdue University School of Mechanical Engineering ATTN: N.M. Laurendeau S.N.B. Murthy D. Sweeney TSPC Chaffee Hall West Lafayette, IN 47906
1	Rensselaer Polytechnic Institute Dept. of Chemical Engineering ATTN: A. Fontijn Troy, NY 12181

No. of Copies	Organization
2	Southwest Research Institute ATTN: R.E. White A.B. Wenzel 8500 Culebra Road San Antonio, TX 78228
1	Stanford University Dept. of Mechanical Engineering ATTN: R. Hanson Stanford, CA 93106
1	University of Texas Dept. of Chemistry ATTN: W. Gardiner Austin, TX 78712
1	University of Utah Dept. of Chemical Engineering ATTN: G. Flandro Salt Lake City, UT 84112
1	Virginia Polytechnic Institute & State University ATTN: J.A. Schetz Blackburg, VA 24061

Aberdeen Proving Ground

Dir, USAMSAA
ATTN: AMXSY-D
AMXSY-MP, H. Cohen
Cdr, USATECOM
ATTN: AMSTE-TO-F
Cdr, CRDC, AMCCOM
ATTN: SMCCR-RSP-A
SMCCR-MU
SMCCR-SPS-IL

USER EVALUATION SHEET/CHANGE OF ADDRESS

This Laboratory undertakes a continuing effort to improve the quality of the reports it publishes. Your comments/answers to the items/questions below will aid us in our efforts.

1. BRL Report Number____________________ Date of Report__________

2. Date Report Received______________________________

3. Does this report satisfy a need? (Comment on purpose, related project, or other area of interest for which the report will be used.)__________

4. How specifically, is the report being used? (Information source, design data, procedure, source of ideas, etc.)__________

5. Has the information in this report led to any quantitative savings as far as man-hours or dollars saved, operating costs avoided or efficiencies achieved, etc? If so, please elaborate.__________

6. General Comments. What do you think should be changed to improve future reports? (Indicate changes to organization, technical content, format, etc.)

CURRENT ADDRESS

Name

Organization

Address

City, State, Zip

7. If indicating a Change of Address or Address Correction, please provide the New or Correct Address in Block 6 above and the Old or Incorrect address below.

OLD ADDRESS

Name

Organization

Address

City, State, Zip

(Remove this sheet along the perforation, fold as indicated, staple or tape closed, and mail.)

FOLD HERE

Director
U.S. Army Ballistic Research Laboratory
ATTN: SLCBR-DD-T
Aberdeen Proving Ground, MD 21005-5066

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO 12062 WASHINGTON,DC

POSTAGE WILL BE PAID BY DEPARTMENT OF THE ARMY

Director
U.S. Army Ballistic Research Laboratory
ATTN: SLCBR-DD-T
Aberdeen Proving Ground, MD 21005-9989

FOLD HERE

END
10-86
DTIC